Quantitative study of invertebrate groups in the soil and ground layer of the IBP sites at Kevo, northern Finland

SEPPO KOPONEN and MIRJA-LIISA OJALA

KOPONEN, SEPPO, & OJALA, MIRJA-LIISA. Quantitative study of invertebrate groups in the soil and ground layer of the IBP sites at Kevo, northern Finland. Rep. Kevo Subarctic Res. Stat. 12. 45—52. 1975. — The number of Acarina per sq. m varied from approx. 44 700 to 289 800 and that of Collembola from 7 800 to 52 000. The lowest densities were found in alpine heath in September. The maximum density of mesofauna was observed in June: 1197 ind./m² in pine forest, 976 in birch forest, and 478 in alpine heath. Abundant groups were e.g. Hemiptera (mean 189 ind./m²) and Diptera larvae (201) in pine forest, Araneae (234), in alpine heath.* The most numerous mesofaunal groups in pitfall trap material were Coleoptera (30 %), Diptera, Araneae, Phalangida, and Hymenoptera. The diversity of fauna in alpine heath was clearly less than in forest sites, and clearly fewer southern groups were observed there than in other sites at Kevo and in IBP sites in Norway and the British Isles.

Department of Zoology, University of Turku, SF-20500 Turku 50, Finland

* Coleoptera larvae (154) and adults (62) in birch forest, and Diptera larvae (132)

1. Introduction

Sedgeland and shrubland tundras chracterized by the absence of trees and tall bushes are typical habitats of the real tundra zone. In such areas the vast majority of the invertebrate fauna lives in the soil and ground layer. Consequently, the main attention in the zoological investigations of the International Biological Programme in the real tundra area of the USSR and North America has been paid to soil and ground layers. In the IBP work at Kevo, situated in the mountain birch forest zone ('forest tundra') of Fennoscandia, the main study object was the fauna of vegetation layers. The investigations of soil fauna were less detailed and made for the most part at the group (order or family) level.

Only a few quantitative investigations of the invertebrate fauna inhabiting the soil and ground layer in northern Fennoscandia have been made (e.g. AGRELL 1941; FORSSLUND 1944; DALENIUS 1960; HUHTA et al. 1967). In the present paper, some information on abundance relations of invertebrate groups inhabiting the soil and ground layer from three habitats in the Fennoscandian forest tundra zone is given.

2. The study area

The study area was situated near the Kevo Subarctic Research Institute in northernmost Finnish Lapland (69° 45' N., 27° E.). Studied sites were pine and birch forests and low alpine heath.

The moss layer of pine (*Pinus sylvestris*) forest was patchy and thin (0.5—4 cm) and consisted of *Pleurozium schreberi, Ptilidium ciliare,* and *Dicranum fuscescens.* There were also lichens (*Cladonia* spp. and *Stereocaulon paschale).* The short field layer of this dry site consisted of *Vaccinium vitis-idaea* and *Empetrum hermaphroditum.* The humus layer was 1.5—5 cm, and the pine forest lies 90 m above sea level.

The moss layer of mountain birch (*Betula tortuosa)* forest was thick (1—10 cm) and dominated by *Pleurozium schreberi* and *Hylocomium splendens.* The field layer consisted of many species (e.g. *Empetrum, Vaccinium* spp., *Ledum palustre*). The humus layer varied from 1 to 8 cm. The birch forest site lies on the northern slope of a hill, approx. 140 m a.s.l.

The ground and field layer of low alpine heath consisted of e.g. *Stereocaulon paschale, Dicranum fuscescens, Ptilidium ciliare, Empetrum,* and *Vaccinium vitis-idaea.* The lichen and moss layer of this rather barren site was 0.5—3 cm and the

humus layer 1—7 cm. The low alpine heath site is situated on the top of Jesnalvaara fell, about 310 m a.s.l.

3. Material and methods

The microfaunal material was collected using a steel borer (area 10.5 cm^2). Animals were extracted using dry Tullgren funnels with 40 W lamps for five days (Acarina and Collembola) and wet Baermann funnels with 40 W lamps for 24 hours (Nematoda). The mesofaunal samples were taken using 25 × 25 cm squares and extracted by large Tullgren funnels (see HUHTA 1972) with 40 W lamps for seven days. Fifty three microfaunal samples were taken from low alpine heath, 60 from pine forest, and 94 from birch forest and, similarly, 24, 24, and 52 mesofaunal samples. These funnel samples were taken in June—September of 1973.

The surface-active mesofauna was studied using pitfall traps with ethylene glycol from the year 1969 onward (cf. KOPONEN 1971). The trapping periods were: July 1 — September 10, 1969; June 9 — September 17, 1971; June 26 — September 11, 1972 (not in pine forest); June 5, 1973 — June 6, 1974 including four subperiods. The mouth Ø of traps in forest sites was 56 mm and in alpine heath 44 mm. The total number of mesofaunal invertebrates collected by traps was 38 829.

Some experiments to test the efficiency of hand-sorting (sieving) were made. Samples (25 × 25 cm) were sieved carefully in the laboratory in good light conditions; the studied moss and humus material was then placed in large Tullgren funnels for six days. The percentages of the total individual number (sieving & funnels) found during the sieving phase were as follows:

	S. Koponen (n = 8)	M-L Ojala (n = 7)
Araneae	85 %	86 %
Coleoptera adults	44	47
Insecta adults	46	28
Insecta larvae	23	19

The results obtained by both authors agree well; only spiders (cf. HUHTA 1972) were found rather well by hand-sorting. Especially Insecta larvae were greatly under-estimated in hand-sorted material. However, hatching and emergence in funnels is a source of error, especially in insect material but also in spiders (see HUHTA 1972). Because of its low efficiency the hand-sorting method was rejected.

4. Results

4.1. Microfauna

The numbers of Acarina and Collembola per sq. m ± S.E. are given in Table 1. The numbers of Acarina were about 3—8 -fold those of Collembola. The highest numbers of microfauna were observed both in alpine heath and birch forest during summer months. In pine forest a very clear maximum density was noted in autumn (September). Conversely, densities in alpine heath were very low in September. The dominant group among Acarina was Cryptostigmata (mainly Oribatida), about 60—75 % of mites. The most abundant Collembola family was Isotomidae. Oribatida and Isotomidae are also typical and abundant groups of microfauna in the True Arctic (see HAMMER 1937; CHERNOV et al. 1971; ANANJEVA 1973).

An estimate of the live biomass of Acarina and Collembola per sq. m was made in August 1973 (Table 2). The three samples from pine forest and alpine heath represented samples with rather high mite and springtail densities, an seven samples from birch forest were chosen randomly. The highest biomass was found in alpine heath.

A characteristic feature of the IBP sites of real tundra areas is the large number of Collembola per area unit compared with that of Acarina (cf. e.g. CHERNOV et al. 1971; BLISS et al. 1973). At Kevo sites, the density of Acarina was very high compared with that of Collembola; thus Kevo, on the basis of microfaunal abundance relations, might better be assigned to the forest zone (cf. data of HUHTA et al. 1967). The same is true also for the Swedish IBP site at Abisko (cf. LOHM et al. 1973). In studied areas in the True Arctic (and also to some extent at the alpine IBP site in Norway), the proportion of Collembola was very high (HAMMER 1937; CHERNOV et al. 1971; SOLHÖY 1972; ANANJEVA et al. 1973; CHERNOV 1973; BLISS et al. 1973).

If the present data are compared with densities obtained by HUHTA et al. (1967) from Central Finnish Lapland, the figures are rather similar.

The number of large, active Nematoda in birch forest was 115 000, in pine forest 42 000, and in low alpine heath 33 000 ind./m^2. Because of the extracting method used (wet funnels) these figures can be compared only with each other.

Table 1. The numbers of Acarina and Collembola per square metre (with S. E.) in the IBP sites at Kevo, 1973.

Pine forest

	June	July	August	September
Acarina	116 847 ± 25 719 (n = 12)	103 958 ± 12 323 (n = 17)	114 359 ± 21 904 (n = 17)	289 768 ± 53 808 (n = 6)
Collembola	18 957 ± 4 253 (n = 12)	26 987 ± 4 802 (n = 17)	13 550 ± 2 818 (n = 17)	50 020 ± 10 413 (n = 6)

Birch forest

	June	July	August	September
Acarina	109 417 ± 10 256 (n = 21)	136 712 ± 22 288 (n = 30)	210 975 ± 21 095 (n = 26)	117 911 ± 24 032 (n = 11)
Collembola	15 051 ± 2 199 (n = 21)	23 928 ± 3 653 (n = 28)	39 115 ± 4 734 (n = 26)	24 590 ± 5 349 (n = 11)

Low alpine heath

	June	July	August	September
Acarina	212 666 ± 17 064 (n = 6)	102 377 ± 25 742 (n = 18)	171 461 ± 22 845 (n = 18)	44 731 ± 16 400 (n = 5)
Collembola	28 037 ± 5 864 (n = 6)	38 073 ± 7 246 (n = 18)	52 038 ± 9 635 (n = 18)	7 838 ± 2 124 (n = 5)

Table 2. Live biomass estimation of Acarina and Collembola at Kevo, August 1973 (g/m²).

	Pine forest	*Birch forest*	*Low alpine heath*
Acarina	1.63 ± 0.50	2.75 ± 0.71	3.46 ± 0.82
Collembola	0.23 ± 0.08	0.40 ± 0.15	0.61 ± 0.13
n	3	7	3

Table 3. Density of soil and ground layer mesofauna (numbers per sq. m with S.E.) in pine and birch forest sites at Kevo, 1973.

	June				July				August			
	pine forest		birch forest		pine forest		birch forest		pine forest		birch forest	
Araneae	112.0 ±	47.3	267.2 ±	67.9	106.0 ±	32.3	228.0 ±	36.9	120.0 ±	11.7	220.7 ±	23.1
Linyphiidae & Theridiidae	98.7	48.1	238.7	64.3	90.0	31.1	200.0	39.3	84.8	11.9	173.3	21.2
Phalangida	0		12.0	9.3	0		1.0	1.0	0		0.7	0.7
Insecta adults	704.0	242.8	381.3	42.0	498.8	61.2	315.0	28.1	176.0	32.4	180.7	21.0
Coleoptera ad.	24.0	12.2	53.0	12.6	34.0	10.2	59.0	9.7	36.8	7.9	68.7	11.3
Diptera ad.	120 0	29.1	189.3	32.8	94.0	24.3	78.0	17.5	11.2	4.2	10.0	4.8
Hemiptera	496.0	212.4	118.7	35.7	142.0	34.8	109.0	18.7	43.2	8.6	66.7	11.9
Insecta larvae	376.0	116.6	314.7	43.1	316.5	38.0	215.0	42.7	409.6	77.3	432.0	70.9
Coleoptera l.	80.0	17.0	213.3	30.3	155.4	23.2	138.0	33.5	198.4	51.5	134.7	16.4
Diptera larv.	296.0	117.4	101.3	23.9	150.0	42.3	73.0	17.4	185.6	64.0	286.0	66.2
Total ~~meso-~~ macro fauna	1197.3	340.1	975.7	124.8	923.3	104.5	760.0	67.2	710.6	80.9	839.9	70.2
n	6		12		8		16		10		24	

4.2. *Mesofauna collected by funnels*

The individual numbers of main mesofaunal groups per sq. m are given in Tables 3—4. The total numbers of mesofauna per sq. m were clearly higher in pine and birch forests than in low alpine heath. The highest densities of Araneae, Coleoptera adults and larvae, and Diptera adults were found in birch forest, and of Hemiptera and Diptera larvae in pine forest. In Diptera there can be seen a phenological tendency: the number of adults decreased violently from June to August, and the number of larvae was lowest in July.

Densities of mesofounal animals at Kevo were higher than observed in C Finnish Lapland (HUHTA et al. 1967) an in *Vaccinium* type forest in northern Sweden (FORSSLUND 1944). In arctic IBP tundra sites, especially in wet tundra, the density of Diptera (e.g. Tipulidae larvae) is very high compared with data from Kevo (HOLMES 1966; RYAN 1972; CHERNOV 1973). A typical feature of

Table 4. Density of soil and ground layer mesofauna (numbers per sq. m with S.E.) in low alpine heath at Kevo, 1973.

	June		July		August	
Araneae	29.3	± 11.3	100.0	± 35.9	115.7	± 29.7
Linyphiidae & Theridiidae	24.0	9.0	98.0	36.1	102.9	29.7
Insecta adults	224.0	51.9	138.0	35.8	88.0	27.6
Coleoptera ad.	2.7	2.7	34.0	27.5	17.6	6.1
Diptera ad.	152.0	54.1	60.0	17.8	4.8	2.4
Insecta larvae	222.3	53.9	120.0	37.4	193.2	63.7
Coleoptera larv.	58.7	18.8	36.0	7.9	20.8	5.9
Diptera larvae	161.0	58.5	72.0	37.8	162.8	62.5
Total mesofauna	478.3	93.3	366.3	63.2	400.1	85.8
n	6		8		10	

Table 5. The total mesofaunal material from pitfall traps at the IBP sites in Kevo (1969, 1971, 1972, 1973).

	Total	*Pine forest*	*Birch forest*	*Low alpine heath*
Coleoptera adults	10535	5467	3318	1750
Diptera adults	7849	2074	3670	2105
Araneae	7690	2672	3591	1427
Phalangida	4688	1239	1680	1769
Hymenoptera adults	3092	741	1591	760
Hemiptera	1285	662	472	151
Homoptera	1120	174	73	873
Coleoptera larvae	1068	617	368	83
Psocoptera	712	645	59	8
Diptera larvae	272	97	37	138
Lepidoptera larvae	152	69	27	56
Gastropoda	140	0	140	0
Chilopoda	70	37	6	27
Hymenoptera larvae	39	4	8	27
Blattoidea	31	1	30	0
Lepidoptera adults	30	13	0	17
Neuroptera adults	19	14	5	0
Plecoptera adults	15	11	3	1
Neuroptera larvae	13	10	0	3
Mecoptera adults	6	2	1	3
Lumbricidae	3	2	1	0
Total	38829	14551	15080	9198

Kevo sites was the very low density of Lumbricidae: no specimens in funnel material.

4.3. Mesofauna collected by traps

The total mesofaunal material from pitfall traps is given in Table 5. The most numerous group was Coleoptera, adults 27.1 % and larvae 2.8 % of total mesofauna. The dominant family among trapped Coleoptera was Staphylinidae; e.g. in period June 5—September 5, 1973, 88 % of Coleoptera individuals in birch forest, 87 % in pine forest, and 42 % in alpine heath. Also Diptera (mainly Nematocera: 92 % of Diptera adults), Araneae (Linyphiidae — 64%, Lycosidae — 25 %), Phalangida *(Mitopus morio),* and Hymenoptera (mainly Parasitica — 95 %) were collected in large numbers. In pine forest were Coleoptera, Psocoptera, Hemiptera, and Chilopoda, in birch forest Araneae, Gastropoda, Hymenoptera, and Blattoidea, and in alpine heath Phalangida and Homoptera especially numerous and typical. The number of recorded taxa was lowest in alpine heath, where e.g. Lumbricidae, Gastropoda, and Blattoidea were absent. The individual numbers in Table 5 are not directly comparable between sites, because of different trapping times and trap mouth diameters.

The phenology of the most abundant groups during four periods (from June 5, 1973 to June 6, 1974) is given in Table 6. The highest percentage of Coleoptera was noted in winter or late summer and the lowest in mid-summer. The abundance of Coleoptera during winter trapping was, especially in pine forest, very high (Staphylinidae). There was a high percentage of Araneae in winter in birch forest and alpine heath (Linyphiidae) and, in early summer, in pine forest and alpine heath (Lycosidae). The percentage of adult Diptera fluctuated least during the trapping periods. The orders Hemiptera, Homoptera, and Psocoptera were abundant (or active) during mid- and late summer. The highest percentage of Phalangida *(M. morio)* was in early and mid-summer; however, these specimens were juveniles. Of all mesofauna, birch forest had the most stable figure during the study year in Table 6. Both pine and birch forests had high winter numbers, while in alpine heath both autum and winter numbers were very low.

Table 6. Percentual proportion of the most abundant groups in trap material during four periods (June 5, 1973 — June 6, 1974) in the IBP sites at Kevo.

Pine forest June 5 — July 5	July 5 — Aug 5	Aug 5 — Sept 5	Sept 5 — June 6
Coleoptera adults 43.7	14.2	37.0	73.9
Coleoptera larvae 2.5	0.2	1.0	11.6
Araneae 30.6	19.6	6.5	6.4
Diptera adults 12.0	10.9	10.1	4.3
Hemiptera 0.0	16.9	15.2	0.5
Phalangida 6.4	11.4	2.8	1.1
Psocoptera 0.7	13.7	12.5	0.1
n 2289	2616	895	3555
Birch forest			
Coleoptera adults 14.2	8.8	54.8	46.1
Araneae 11.8	19.5	15.1	33.9
Diptera adults 29.8	21.4	7.1	12.3
Phalangida 29.1	22.2	2.8	0.3
Hemiptera 0.6	5.0	8.4	1.8
n 1865	1731	1526	2746
Low alpine heath			
Coleoptera adults 29.9	5.5	33.5	37.9
Phalangida 29.0	23.3	4.5	7.3
Araneae 20.1	11.7	5.6	23.3
Diptera adults 13.3	17.3	18.2	7.8
Homoptera 0.1	33.8	14.2	4.2
n 1152	2205	269	383

Table 7. Numbers of some groups and species at the IBP sites at Kevo (trap material).

	Pine forest	*Birch forest*	*Low alpine heath*
Number of main mesofaunal groups	15	16	13
Number of Insecta orders	11	11	10
Number of Araneae species	56	55	39
Number of Linyphiidae species	35	35	23
Number of Coleoptera species	67	61	42

Table 8. Number of species of certain groups at IBP/Tundra Biome sites in England, Ireland, Norway, Finland, USA, and Canada.

	Moor House (England)	*Glenamoy* (Ireland)	*Stigstuv* (Norway)	*Kevo total* (Finland)	*Kevo alpine heath* (Finland)	*Point Barrow* (Alaska, USA)	*Devon Island* (Canada)
Lumbricidae	13	2	3	1	0	1	0
Gastropoda	>7	8	8	5	0	0	0
"Myriapoda"	6	4	0	1	1	0	0
Isopoda	1	3	0	0	0	0	0
Phalangida	3	2	1	1	1	0	0
Total	>30	19	12	8	2	1	0

4.4. Diversity of sites

The nature of the IBP sites at Kevo is very different; two sites are forest and the third alpine heath. Some information on the faunal diversity of sites, based on trapping material, is given in Table 7. The diversity (numbers of groups and species) in birch and pine forests were very similar, and greater than in alpine heath. Also the soils of the forest sites are physically similar, and the definitive difference is the "better" quality of organic matter (plant litter) in birch forest (BAKER 1974). The small trapping area (10 x 25 m) at each site must be borne in mind when considering Table 7.

Many mesofaunal groups occurring in considerable species and individual numbers at IBP sites in more temperate area (e.g. in the British Isles) are absent or only a few species are found to occur at Kevo. Of the following groups only one species lives at Kevo: Lumbricidae (*Dendrobaena octaedra*), Chilopoda (*Lithobius curtipes*), Phalangida (*Mitopus morio*), and Blattoidea (*Ectobius lapponicus*). The occurrence of some "southern", well-known groups at certain sites of the IBP/Tundra Biome project is shown in Table 8 (partly based on RYAN unpubl. and SOLHÖY in litt.).

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